Vibrating Wire Precision Water Level Meter
User Manual

Man213	1.1.1	07/08/2014	P. Day	Chris Rasmussen	Chris Rasmussen
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Contents

Section 1 : General Information

1.01 Description

The Precision Water Level Meter (PWLM) consists of a cylindrical weight suspended from a vibrating wire strain gauge, housed within a plastic stilling well.

The PWLM is designed to measure water levels in streams, weirs and boreholes where accurate measurements of small water level changes are required.

1.02 Operating Principle

The weight connected to the strain gauge has a specific gravity that is slightly greater than that of water. The strain gage works by measuring the load exerted by the weight's buoyant forces as the water level changes in relation to the fixed position of weight.

The change in load changes the wire's tension and resonant frequency. The readout box supplies an electrical pulse to the coil/magnet assembly, which in effect plucks the wire and causes it to vibrate at its resonant frequency. The coil/magnet assembly then acts as a pickup as the oscillations of the wire through the magnetic field induce an alternating current in the coil, which is detected by the readout. The readout converts the sinusoidal alternating voltage to a square wave from which may easily be timed using a frequency oscillator. In this way the period of oscillation may accurately be measured. The relationship between a change in the period of oscillation and the strain of the wire is non-linear, so to facilitate the reading procedure the readout converts the period of oscillation to frequency-squared which has a linear relationship to strain.

1.03 Performance

The PWLM has a very good long-term stability but are sensitive to temperature, and an allowance for temperature variations may be necessary when interpolating the results. The PWLM's can accommodate a thermistor to monitor temperature if such variations are anticipated.

Section 2 : Installation of Precision Water Level Meter

2.01 Test Prior to Installation

Before installation the PWLM should be subjected to an operational test with the portable readout connected as follows:-

Suspend the PWLM and gently attached the weight, loosen the two transit screws that secure the weight hanging hook. The hook should hang freely and not be in contact with the body or the transit screws. Take a zero reading, which should be of a constant value.

Transit Screw   Transit Screw
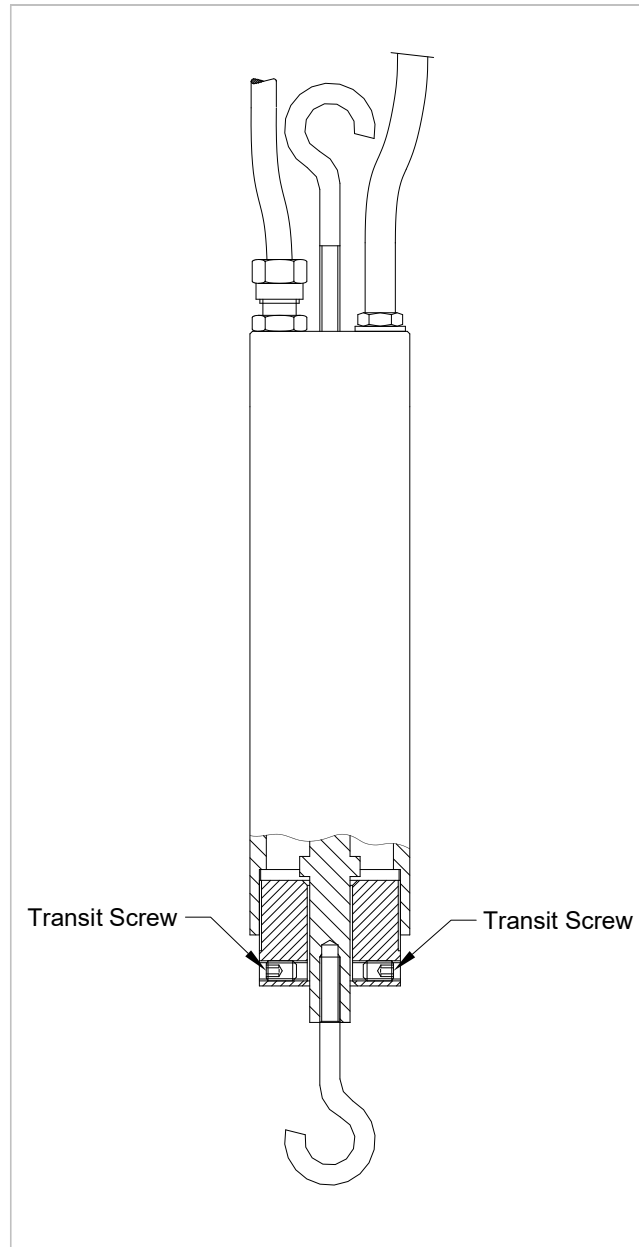
2.02 Cable Connection and Potting

PWLM's are usually supplied with 5 metre of cable already connected to the transducer. Additional cable lengths may be added on site using a cable jointing kit, see section 2.04.

2.03 Installation

The stilling well should be installed vertically in a position where there is little water turbulence. The vertical position should be such that the weight of the PWLM will be in the desired position relative to the water level. After installation of the stilling well connect the PWLM to the cap of the stilling well and lower the assembly into the stilling well.

It is important that the PWLM is centred within the stilling well and that the weight is not touching the side of the stilling well as this will influence the sensor output.

After installation the seal screw should be removed from the moisture trap. The trap should be positioned in a dry environment away from the stream or weir.

The installation zero reading should now be taken and recorded for later use in data reduction.

It is advisable to test the PWLM by raising the cap a few centimetres and recording the change in reading and then calculating the change in engineering units.

This will ensure that you are aware of the direction of change of the engineering units, raising the cap simulates a drop in water level.

You can reverse the indicated direction of change by reversing the sign of the K or G factor.

2.04 Cable Jointing

It is desirable to minimise cable joints, but where they are unavoidable a special joint kit may be supplied. The effectiveness of this joint largely depends on the care with which the jointing operation is carried out.

2.04.1 Preparation of the Cable

Thoroughly scrape all wax and dirt from each cable and for approximately 150mm. Prepare the cable ends exactly as shown in Figure 5. Stagger the individual conductor connections.

2.04.2 Conductor Connections

Use the crimped connectors to join the conductors and use the electrical insulation tape to wrap the connectors. Stretch the tape to half its original width and apply one layer half lapped over connector area only (Figure 6). Do not warp the tape beyond the pencilled area.

2.04.3 Fitting Mould

Trim the ends of the mould with a sharp knife to suit the diameter of the cable. Hold the mould halves in place centred over the splice. Snap both halves together and fit the pouring spouts in the holes. Ensure that both seams are completely snapped together. Tape the ends of the mould body to form a seal.

2.04.4 Filling with Resin

Mix the resin thoroughly and maintaining the mould in a level position, spouts uppermost, pour the resin through one spout until both spouts are completely filled. When the resin has solidified and cooled remove the spouts.

NOTE: In cold weather (below 15°C) the resin becomes very viscous. It is therefore advisable to keep the resin in a warm place prior to mixing. Mix the compound until its temperature starts to rise, this decreases the viscosity.

Section 3 : Termination of Cables

The cables are normally terminated in a 5-channel terminal box or 12 and 24 channel terminal units. The cables enter through waterproof glands. The terminal box has a cover secured by four screws whereas the terminal units have a hinged lid. The cables are terminated as follows:-

Unscrew the cover or open the lid as appropriate. Unscrew the four fixing screws holding the terminal panel and carefully remove it without straining the connecting leads.

Prepare the cables by stripping and cutting back 20cm approximately of the outer insulation and armour. Remove the rubber packing and strip back 5cm of the conductor insulation.

Slacken the entry glands and insert the cables. Make connections to the contact block (details of colour coding supplied with each instrument). Retighten the glands to grip the cables.

Replace the terminal panel and secure. Connect the readout to each instrument in turn to check connections.

Section 4 : Vibrating Wire Precision Water Level Meter Data Reduction Procedures

4.01 The Calibration Certificate

The end of this section shows example of the Calibration Certificate as supplied with each PWLM.

4.02 Data Reduction

The mathematical relationship between the frequency of vibration of a tensioned wire and the force applying the tension is an approximate straight line relationship between the square of the measured frequency and the applied force.

Engineering units of measurement maybe derived from the frequency-based units measured by vibrating wire readouts, in 2 traditional ways:-

From 'Period' units and from 'Linear'(F^2/1000) units.

Calculation using 'Period' units

The following formula is used for readings in 'Period' units.

$E = K (10^7/P0^2 - 10^7/P1^2)$

Where;

E is the Pressure in resultant Engineering units,

K is the Period Gauge Factor for units of calibration (from the calibration sheet), P0 is the Period 'base' or 'zero' reading

P1 is the current Period reading.

This method of calculation is used by the Soil Instruments Vibrating Wire loggers' (models RO-1-VW-1 or 2 and with serial numbers starting VL or TVL) internal processors', for calculating and displaying directly on the loggers' LCD screen, the required Engineering based units.

The loggers' require 'Period' base or zero reading units for entering into their channel tables, to calculate and display correctly the required engineering units.

If an Engineering-based unit is required other than the units of calibration, then the correct K factor will have to be calculated using the standard relationship between Engineering units.

For example, if the units of calculation required were in KGF/Cm^2 and the calibration units were kPa, we can find out that 1kPa is equal to 0.01019 KGF/Cm^2, so we would derive the K factor for KGF/Cm^2 by multiplying the K factor for kPa by 0.01019

Please see conversion factors in Section 10.

Calculation using Linear units

The following formula is used for readings in 'Linear' units.

$E = G (R0 - R1)$

Where;

E is the resultant Engineering unit,

G the linear Gauge factor for the units of calibration (from the calibration sheet), R0 is the Linear 'base' or 'zero' reading

R1 is the current Linear reading.

Again the Linear gauge factor for units other than the units of calibration would need to be calculated using the same principles as stated in the last paragraph of the 'Period unit' section.

Appendix A.   Example of Calibration Sheet – Vibrating Wire PWLM

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TN22 1QL United Kingdom   t: +44 (0) 1825 765044   e: info@soilinstruments.com   w: www.soilinstruments.com

Soil Instruments Limited. Registered in England. Number: 07960087. Registered Office: 3rd Floor, 1 Ashley Road, Altrincham, Cheshire, WA14 2DT, UK

VIBRATING WIRE INSTRUMENT CALIBRATION CERTIFICATE

Sensor Type	**Water Level Transducer**	Transducer Serial No	**21676**
Range	**0-300mm**	Weight Serial No	**21676**

Works Calibration Data

Calibration Equipment Which is Traceable to National Standards

Calibrated Weight Set soil Instruments Equipment No.1160
Vibrating Wire Readout 5351

Date	**6-Feb-2017**	Period Gauge Constant (mm) (K)	**3.690004**
Ambient Temp	**22°C**	Period Gauge Constant (gramms) (K)	**-2070.7526**
Calibrated By	**M.Bratton**	F²/1000 Gauge Constant (mm/Digit) (G)	**-0.0003690**
Weight Ave Diameter (mm)	**845.29**	F²/1000 Gauge Constant (gramms/Digit) (G)	**0.2070753**
Weight Volume Factor (V)	**561.1789**		

WATER LEVEL TRANSDUCER CALIBRATION

Applied Load (Grams)	Calculated Readings	Full Scale Error (%)
0.00	0.00	0.00
198.55	197.99	-0.05
394.97	394.51	-0.04
592.97	591.28	-0.14
791.64	787.13	-0.38
989.99	990.25	0.02
1188.26	1188.26	0.00

The instrument detailed hereon has, as applicable, been tested and calibrated in accordance with procedures, which are part of our ISO9001:2015 Quality Management System and unless otherwise indicated, performs within +/- 0.50% as specified. Thus, the instrument conforms in all respects to our relevant specifications and drawings.

Certified By   _____   Line Manager

Appendix B. Conversion Factor Chart

Pressure, Stress & Modulus of Elasticity										
MN/m² or MPa	kN/m² or kPa	kp or kgf/cm²	bar	atm	m H_2O	ft H_2O	mm Hg	tonf/ft²	psi or lbf/in²	lbf/ft²
1	1000	10.197	10.000	9.869	102.2	335.2	7500.6	9.320	145.04	20886
0.001	1	1.019×10^{-2}	0.0100	9.87×10^{-3}	0.1022	0.3352	7.5006	0.0093	0.14504	20.886
9.807×10^{-2}	98.07	1	0.9807	0.9678	10.017	32.866	735.56	0.9139	14.223	2048.1
0.100	100.0	1.0197	1	0.9869	10.215	33.515	750.06	0.9320	14.504	2088.6
0.1013	101.33	1.0332	1.0132	1	10.351	33.959	760.02	0.9444	14.696	2116.2
9.788×10^{-3}	9.7885	9.983×10^{-2}	9.789×10^{-2}	9.661×10^{-2}	1	3.2808	73.424	9.124×10^{-2}	1.4198	204.45
2.983×10^{-3}	2.9835	3.043×10^{-2}	2.984×10^{-2}	2.945×10^{-2}	0.3048	1	22.377	2.781×10^{-2}	0.43275	62.316
1.333×10^{-4}	0.1333	1.3595×10^{-3}	1.333×10^{-3}	1.315×10^{-3}	1.362×10^{-2}	4.469×10^{-2}	1	1.243×10^{-3}	1.934×10^{-2}	2.7846
0.1073	107.3	1.0942	1.0730	1.0589	10.960	35.960	804.78	1	15.562	2240.0
6.895×10^{-3}	6.895	7.031×10^{-2}	6.895×10^{-2}	6.805×10^{-2}	0.7043	2.3108	51.714	6.426×10^{-2}	1	144.00
4.788×10^{-5}	4.788×10^{-2}	4.883×10^{-4}	4.788×10^{-4}	4.725×10^{-4}	4.891×10^{-3}	1.605×10^{-2}	0.3591	4.464×10^{-4}	6.944×10^{-3}	1

Appendix C. Troubleshooting

If a failure of any vibrating wire transducer or the electrical cable is suspected, the following steps can be followed. The transducers themselves are sealed and cannot be opened for inspection. The "Troubleshooting Flowchart" should also be followed if any instrument failures are suspected.

The steps below and the Troubleshooting Flowchart are applicable generally to any vibrating wire instrument.

STEP 1

Before any of the following steps are followed, the portable data logger should be used to verify the stability of the reading and the audio signal from the portable logger should be heard. An unstable (wildly fluctuating) reading from a transducer or an unsteady audio signal are both indications of possible problems with instruments or their related electrical cables.

If a portable data logger is giving faulty readings or audio signals from all transducers, a faulty readout unit must be suspected. Another readout unit should be used to check the readings from the transducers and Soil Instruments should be consulted about the faulty readout unit.

STEP 2

The resistance across the two conductors of the electrical cable should be checked. This can be done using a multimeter device across the two exposed conductors if the cable has not been connected to a terminal cabinet, or can be done just as easily across the two conductors if the instrument has been connected to such a terminal (or datalogger).

The resistance across the two conductors should be approximately of the order of 120Ω to 180Ω. The majority of this resistance will come from the transducer (say approximately 130Ω).

Before proceeding to Steps 3 and 4, the continuity should be checked between conductors and earthing screen of the electrical cable. If continuity exists, a damaged cable is confirmed.

STEP 3

If the resistance across the two conductors is much higher than the values quoted in "STEP 1" (or is infinite), a severed cable must be suspected.
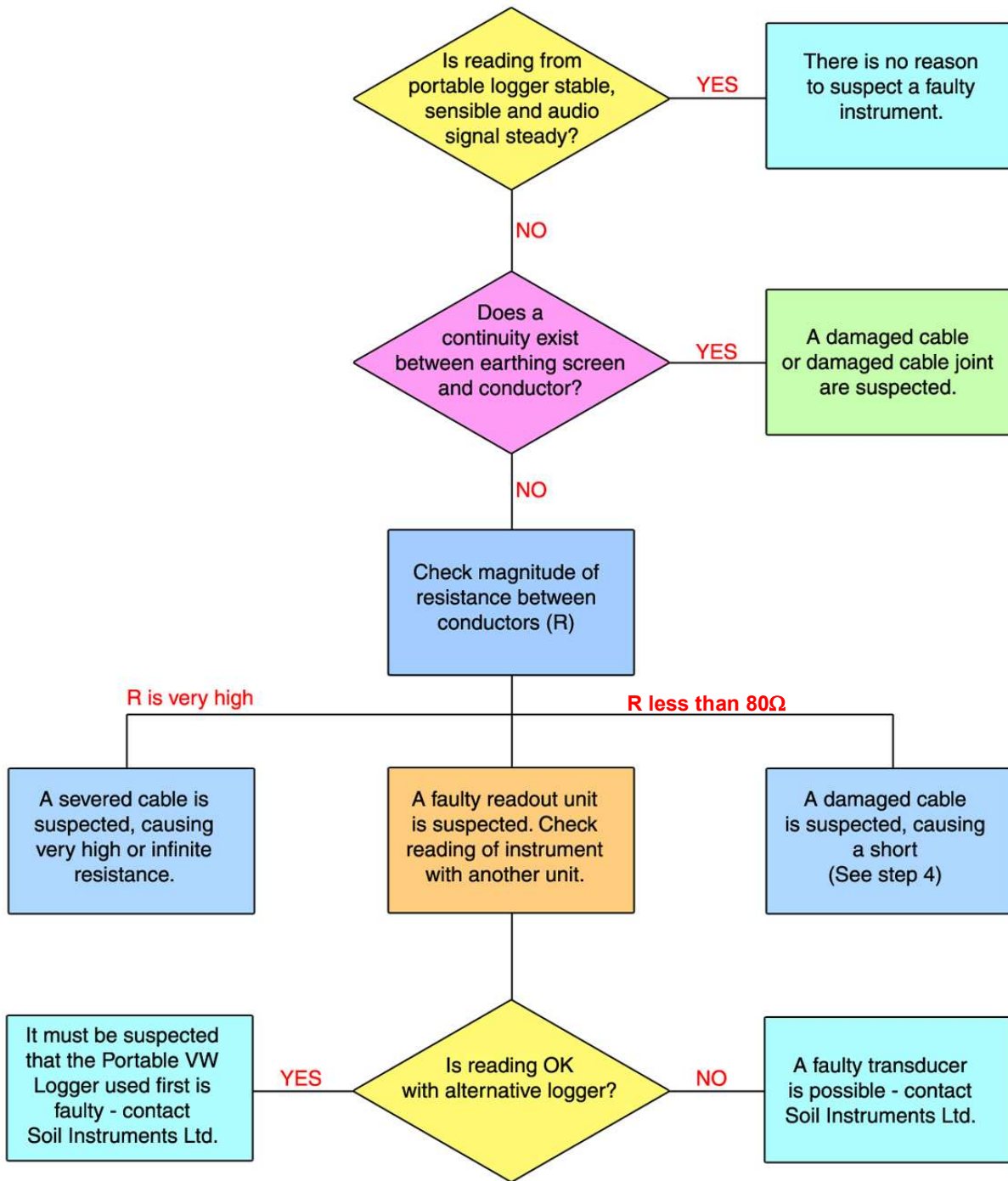
STEP 4

If the resistance across the two conductors is much lower than the values quoted in "STEP 1" (say 80Ω or less) it is likely that cable damage has occurred causing a short in the circuit.

STEP 5

If the resistance is within the values quoted in "STEP 1" (i.e. 120Ω to 180Ω), AND no continuity exists between conductor and earth screen and on checking the reading from the transducer, it proves to be still unstable or wildly fluctuating, it must be assumed that the integrity of the circuit is good. A faulty transducer could be suspected if neighbouring construction activities do not account for the anomaly Soil Instruments should be consulted.

If the point at which the cable is damaged is found, the cable can then be spliced in accordance with recommended procedures.

TROUBLE SHOOTING FLOWCHART

Is reading from portable logger stable, sensible and audio signal steady?

YES → There is no reason to suspect a faulty instrument.

NO

Does a continuity exist between earthing screen and conductor?

YES → A damaged cable or damaged cable joint are suspected.

NO

Check magnitude of resistance between conductors (R)

R is very high → A severed cable is suspected, causing very high or infinite resistance.

A faulty readout unit is suspected. Check reading of instrument with another unit.

R less than 80Ω → A damaged cable is suspected, causing a short (See step 4)

Is reading OK with alternative logger?

YES → It must be suspected that the Portable VW Logger used first is faulty - contact Soil Instruments Ltd.

NO → A faulty transducer is possible - contact Soil Instruments Ltd.

Appendix D. Declarations

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EU Declaration of Conformity

Soil Instruments Ltd., located at 34 Bell Lane, Uckfield, East Sussex, TN22, 1QL, United Kingdom.

We hereby declare that the devices described below are in conformity with the directives listed. In the event of unauthorised modification of any devices listed below, this declaration becomes invalid.

Type: VW V-Notch Wier Monitor

Product Model: W10 series 2148-100 to 2148-120

This declaration is issued under the sole responsibility of the manufacturer.

The products described above are in conformity with the relevant Union harmonisation legislation:

-RoHS Directive 2011/65/EU
-EMC Directive 2014/30/EU

References to the relevant harmonized standards used in relation to which conformity is declared:

-EN IEC 61326-1:2021 (EMC)
-EN IEC 63000:2018 (RoHS)

Signed for and on behalf of Soil Instruments Ltd

Philip Day

Date: 27 February 2023

Technical Manager,

Issued in: Bell Lane, Uckfield, East Sussex, TN22, 1QL, United Kingdom

UK CA **Declaration of Conformity**

Soil Instruments Ltd., located at 34 Bell Lane, Uckfield, East Sussex, TN22, 1QL, United Kingdom.

We hereby declare that the devices described below are in conformity with the Statutory Instruments listed in accordance with UK Government Guidance. In the event of unauthorised modification of any devices listed below, this declaration becomes invalid.

Type: VW V-Notch Wier Monitor

Product Model: W10 series 2148-100 to 2148-120

This declaration is issued under the sole responsibility of the manufacturer.

Relevant UK Statutory Instruments and their amendments:

2016 No 1091	The Electromagnetic Compatibility Regulations 2016
2012 No 3032	The Restriction of the Use of Hazardous Substances in Electrical and Electronic Equipment Regulations 2012

References to the relevant designated standards used in relation to which conformity is declared:

-EN IEC 61326-1:2021 (EMC)
-EN IEC 63000:2018 (RoHS)
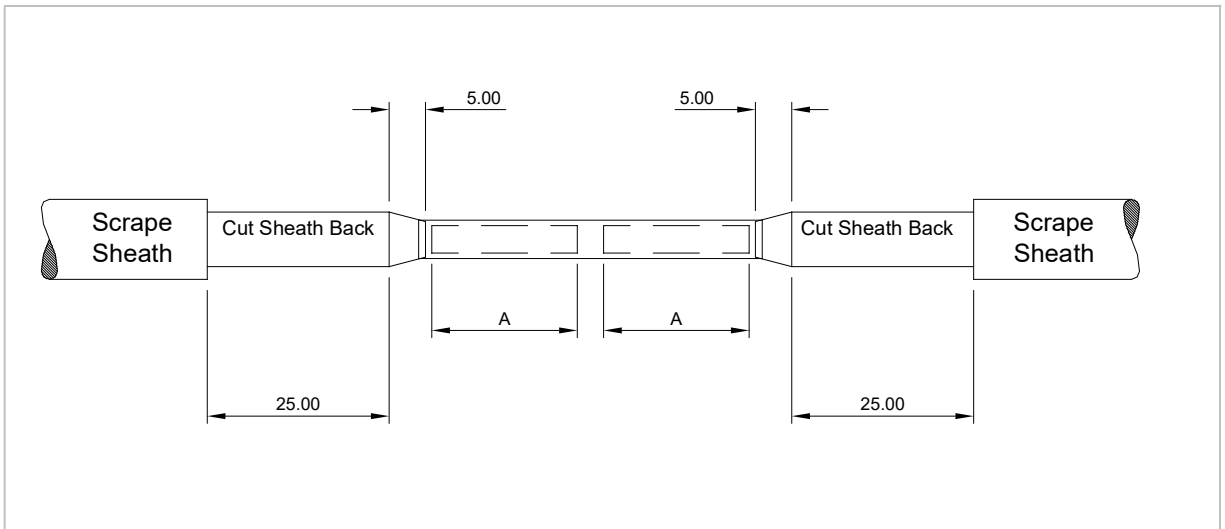
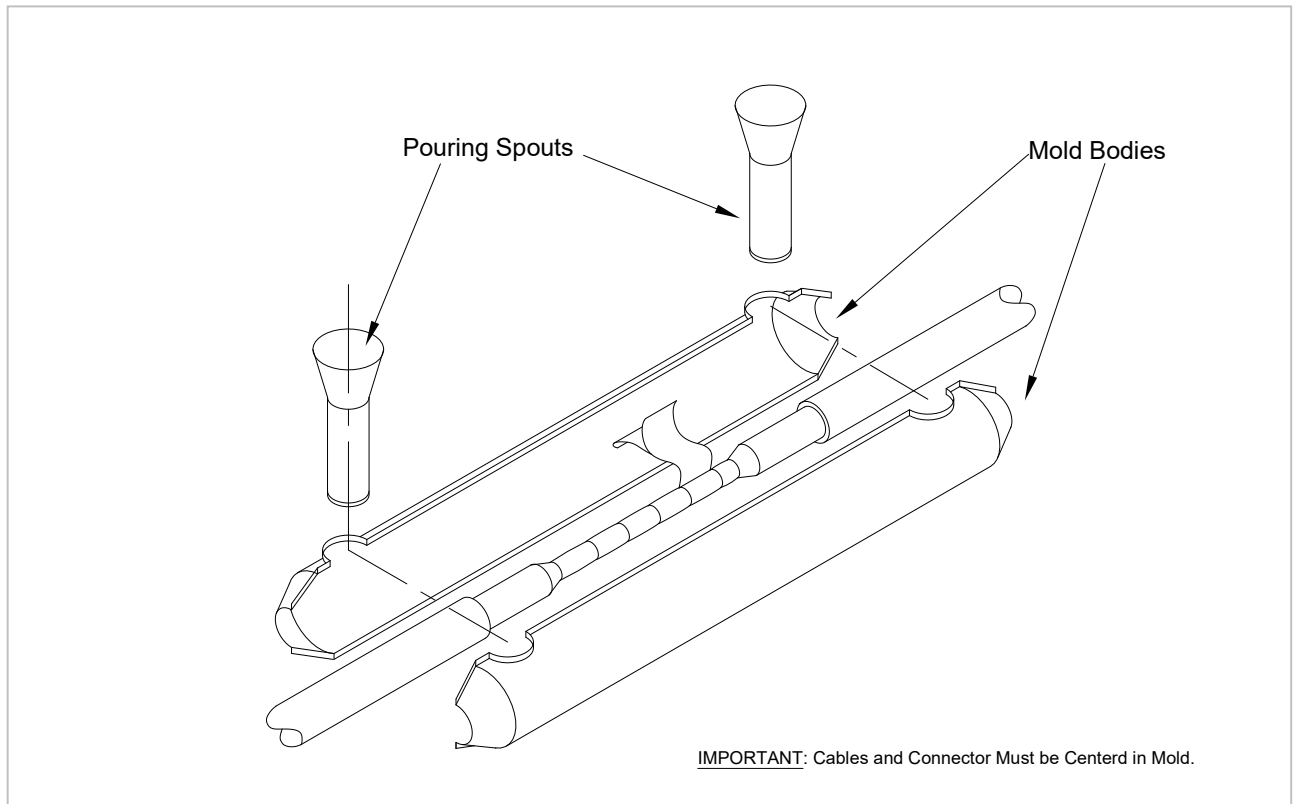Signed for and on behalf of Soil Instruments Ltd

Philip Day

Date: 27 February 2023

Technical Manager,

Issued in: Bell Lane, Uckfield, East Sussex, TN22, 1QL, United Kingdom

Figure 5: Preparation of Cable Joint

Pouring Spouts

Mold Bodies

IMPORTANT: Cables and Connector Must be Centerd in Mold.

Figure 6: Cable Jointing Kit Wrapping Electrical Connectors & Fitting Mould